



Hawton, K., Norris, T., Crawley, E., & Shield, J. P. H. (2018). Is Child Abuse Associated with Adolescent Obesity? A Population Cohort Study. *Childhood Obesity*, 14(2), 106-113.  
<https://doi.org/10.1089/chi.2017.0141>

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## **Is Child Abuse Associated with Adolescent Obesity? : A Population Cohort Study**

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**Manuscript keywords:** Abuse; Adolescence; Overweight; Obesity

**Running title:** Is Child Abuse linked to Adolescent Obesity?

### **Abbreviations:**

ALSPAC = Avon Longitudinal Study of Parents and Children

BMI = Body Mass Index

IL-6 = interleukin 6

IOTF = International Obesity Task Force

WHO = World Health Organisation

### **Acknowledgments:**

The UK Medical Research Council (MRC) and the Wellcome Trust (Grant ref: 102215/2/13/2) and the University of Bristol provide core support for ALSPAC. This research was specifically funded by an MRC research grant (MR/K020269/1). The views expressed in this publication are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health (DH).

### **Disclosure Statement:**

The submitted work had financial support from an MRC research grant; KH was funded by an Elizabeth Blackwell Institute, Bristol, Clinical Primer Award; JPHS is supported through the National Institute for Health Research (NIHR) Biomedical Research Centre Funding Scheme; EC is supported through the NIHR and for work outside this submitted work has received grants from The Linbury Trust and The Ashden Trust.

## **Abstract:**

### **Background**

Child abuse is associated with obesity in adulthood through multiple mechanisms. However, little is known about the relationship between abuse and obesity during adolescence. The aim of this study was to investigate, using a birth cohort, whether there is an association between child abuse and overweight or obesity in adolescence.

### **Methods**

This study utilises data from the Avon Longitudinal Study of Parents and Children (ALSPAC), a prospective cohort study based in South West England. Using data from the 4205 children with complete data at 13 and 16 years we analysed body mass index (BMI) and anonymous parental report of abuse. Abuse was categorised as emotional, physical or sexual. A sub-sample of 3429 had BMI recorded at 18 years enabling a longitudinal analysis of BMI trajectories.

### **Results**

Using linear and logistic regression analysis, adjusting for sex and family adversity, no association was found between child abuse and BMI, BMI Z-scores, overweight or obesity, at 13 or 16 years, with all confidence intervals straddling the null. There was weak evidence of a negative association between physical and emotional abuse and BMI trajectories between 13 and 18 years.

### **Conclusions**

No relationship was found between child abuse and adolescent obesity in this cohort. This challenges the assumption that adolescent obesity is linked to previous child abuse as demonstrated for obesity in adult life. A further longitudinal study utilising both parental and

child reports with data record linkage, to improve reporting of abuse, and including neglect as an abuse category, would be desirable.

**Introduction:**

Childhood abuse, (sexual, physical and emotional) is associated with later adult obesity,<sup>1, 2, 3</sup> with the risk being greater with increasing number of episodes of abuse.<sup>4, 5</sup> However, the evidence is not consistent with studies describing different associations depending on the type of abuse; for example, obesity only being associated with either sexual or physical abuse.<sup>6, 7</sup>

There are a number of proposed mechanisms as to why child abuse may be associated with obesity in adult life. Firstly, there are possible behavioural mechanisms, such as depression and negative affect leading to disordered eating<sup>8</sup>, generalised parental dysfunction leading to disordered sleep and poor diet<sup>4</sup>, and obesity as a defensive mechanism against further episodes of abuse<sup>4, 9</sup>. Additionally, there are possible physiological responses which may occur as a consequence of stress, such as child abuse, that are associated with obesity; including elevated inflammatory markers such as IL-6 (interleukin-6)<sup>10, 11</sup>, chronically elevated cortisol levels leading to increased appetite and visceral adiposity<sup>12</sup>, and epigenetic mechanisms such as hyper-methylation of the PM20D1 gene<sup>13, 14</sup>.

Little is known about the relationship between childhood abuse and obesity in adolescence. A cross sectional study of 147 adolescents in the USA, showed an abuse-specific association, with sexual and emotional abuse showing no association, but physical abuse being positively associated to weight status.<sup>15</sup> However, a number of other studies utilising a combination of cross sectional and prospective methodologies have reported finding no association between child abuse of different types and adolescent obesity<sup>16, 17, 18</sup>. Thus, whilst there is strong evidence for an association between child abuse and adult obesity it is unclear whether or not this association also exists for obesity in adolescence. It is important to understand more about factors potentially associated with obesity, particularly at a younger age, due to its

wide-ranging, individual long-term health consequences, such as diabetes mellitus and hypertension<sup>19, 20, 21, 22</sup>, and its significant costs to the economy.<sup>23</sup> Child abuse also leads to substantial economic cost. The estimated average lifetime cost of non-fatal child maltreatment by a primary care-giver is £89,390, and the cost of child sexual abuse alone in the UK was estimated to be £3.2 billion in 2012.<sup>24</sup>

Given the current uncertainty in the literature regarding an association between child abuse and obesity in adolescence, this study utilises a prospective cohort with a large sample size in order to address this question. Repeated measures of parentally reported sexual, emotional and physical abuse during childhood in the ALSPAC (Avon Longitudinal Study of Parents and Children - <http://www.bristol.ac.uk/alspac/about/>) were used to identify whether any occurrence, or serial episodes of pre-adolescent child abuse are related to weight status in adolescence. It was hypothesised that abuse and obesity may be associated due to the known association between child abuse and obesity in later life.

## **Methods:**

### *Sample:*

ALSPAC is a population based longitudinal birth cohort of children who had an expected date of delivery between April 1991 and December 1992 and whose mothers were resident in the Avon region of South-West England at the time of recruitment.<sup>25</sup> From 14541 pregnancies included, 13978 children were alive at 12 months of age (excluding triplets and quadruplets). 6147 and 5515 adolescents respectively attended the clinic at age 13 and 16 where BMI was measured. The study website contains details of all the data that is available through a fully searchable data dictionary: [www.bris.ac.uk/alspac/researchers/data-access/data-dictionary/](http://www.bris.ac.uk/alspac/researchers/data-access/data-dictionary/). Response rates for the assessments from 4 weeks to 18 years have been described.<sup>25</sup> This analysis includes 4205 adolescents with complete data for child abuse variables (exposure variable) collected during childhood, and BMI at 13 and 16 years (outcome variables). A sub-sample of 3429 also had BMI data at 18 years allowing a further longitudinal analysis to be conducted. Ethical approval for the study was obtained from the ALSPAC 105 Ethics and Law Committee (IRB00003312) and the Local Research Ethics Committees.

### *Variables:*

Obesity: Height (without shoes) was measured to the last complete millimetre using the Harpenden Stadiometer (Holtain Ltd) and weight (without shoes and wearing light clothing only) was measured using the Tanita Body Fat Analyser (Model TBF 305) in ALSPAC research clinics when children were aged approximately 13 years, 16 years, and 18 years. Body mass index (BMI) ( $\text{kg/m}^2$ ) was calculated and converted into sex- and age-specific Z-scores relative to the IOTF (International Obesity Taskforce) reference. These Z-scores were

used to classify children into the recognised BMI categories (underweight, normal weight, overweight, obese), based on published BMI Z-score cut-offs.<sup>26</sup> Prevalence levels of obesity at 13 years and 16 years were also calculated using World Health Organisation (WHO) definition for comparison, whereby obesity is defined as BMI more than 2 standard deviations above the WHO growth standard median.<sup>27</sup> For all subsequent analyses, IOTF definitions and z- scores were used.

Anonymous parental report of abuse: Incidents of maternal and partner-reported child abuse were identified from responses to questions asked in a series of questionnaires when the child was approximately 18, 30, 42, 57, 69, 81 and 103 months (sexual abuse) and 8, 21, 33, 47, 61, 73, 110, and 134 months (physical; emotional abuse). These variables relate to incidents of abuse in the intervening period. For both the physical and emotional abuse, there were four variables, with both the mother and her partner asked two questions about the incidence of abuse. Mothers were asked a) whether she and b) whether her partner had abused the child, and vice versa for the partner. The following phrasing was used in the questionnaires i) “You were physically cruel to your children”, ii) “Your partner was physically cruel to your children”, iii) “You were emotionally cruel to your children” and iv) “Your partner was emotionally cruel to your children”. For the sexual abuse variables however, only mothers reported on whether the child had been abused or not in response to the questionnaire asking in relation to the child if “He/She was sexually abused” during each given time period.

#### *Statistical analysis:*

At each time point, a binary variable was created which represented whether the mother reported that the child had been sexually abused or not. From these, a dichotomous variable



representing any incidence of sexual abuse at any of the seven time points was generated. Due to the small number of mothers reporting more than one episode of sexual abuse (table 2) it was not possible to produce a cumulative sexual abuse variable (to represent repetitive abuse). For the physical and emotional variables, a binary variable was generated at each time point, with a score of 1 being obtained if any of the four variables (two from mother and two from partner) had been answered 'yes' at any of the eight time points. Again, from these both a binary and cumulative abuse variable was generated, representing any and cumulative abuse over the eight time points..

#### *Analyses at 13 and 16 years:*

Logistic regression models were used to investigate the relationship between childhood abuse up to age 11 years and the presence of obesity (0/1) at 13 and 16 years. Linear regression models were used to investigate the association between abuse and the continuous BMI and BMI Z scores. Unadjusted models were firstly run, followed by adjustment for sex and family adversity. Family adversity was a composite measure utilising responses to 14 questions addressing housing, education, social relationships and maternal health assessed prospectively at birth. It was investigated whether relationships between abuse and obesity were different in boys and girls by fitting a logistic regression model with a term for interaction between gender and abuse. Analyses were restricted to those with complete data for the exposure, outcome and covariate data (n=4205).

#### *Longitudinal analysis over adolescence:*

In a sub-sample of participants who had three BMI measurements during adolescence (n=3429), a longitudinal analysis utilising these serially-collected BMI measurements (at 13,

16 and 18) was conducted. This was analysed as a mixed-effects growth model using Stata's 'xtmixed' command to identify whether exposure to abuse in childhood resulted in different trajectories of BMI during adolescence. As trajectories of BMI during adolescence are not linear, it was necessary to transform the age parameter in the mixed-effects model in order to allow for this non-linear pattern over time. As such, a fractional polynomials of one degree was fitted to the BMI data, with the aim of identifying the most suitable age transformation to model the pattern of BMI over time.

This age term was then entered as a random effect in a mixed-effects model, allowing each individual to have their own BMI trajectory. After this base model had been fitted, dummy abuse variables were incorporated to see if those who had experienced any incidence of abuse during childhood were systematically lighter or heavier than those without any incidences of abuse (i.e. is the whole BMI trajectory shifted upwards or downwards?). Specifically, likelihood ratio tests were performed to identify whether the addition of this dummy size variable improved model fit whilst also checking 95% confidence intervals for the added variable. After this, an abuse\*age interaction was incorporated into the model to identify whether those who had experienced any abuse during childhood had different BMI trajectories during adolescence. In such a model, the reported abuse\*age interaction is interpreted as the difference in trajectories (slopes) between those who experienced abuse (compared to those who did not), such that a positive number would suggest that those who were abused had a greater BMI trajectory (slope) during the measurement period, relative to those who were not abused. Once again the 95% confidence intervals of the coefficients were assessed and likelihood ratio tests were run to see if the less restrictive model (compared to the previous model with the dummy size variable) was a better fitting model than the simpler model. As for the cross-sectional analysis, the mixed-effects model was adjusted for sex and

family adversity (n with complete data=3251). All analyses were conducted in Stata/MP v.13.1.

## Results:

It is shown in table 1 that, compared to adolescents with complete data for all exposures and outcome data, those with incomplete data were more likely to be female, come from families with a higher family adversity score and a lower weekly income, and have mothers and their partners who were less likely to have obtained a degree.

Only 19/4205 adolescents were reported to have experienced sexual abuse in childhood (0.45%), with three of these reported to have experienced more than one episode. 284 (6.75%) adolescents were reported to have experienced any physical abuse, with 186 of these experiencing a single episode. 18/4205 adolescents (0.42%) were reported to have experienced four or more episodes. Emotional abuse was reported to have occurred in 17.15% of the sample (n=721). More than 2% of the sample were reported to have experienced 4 or more episodes of emotional abuse (n=87) (Table 2). The median BMI was 19.58 (17.91; 21.86) and 20.59 (18.95; 22.79) at 13 and 16 years, respectively, with females having a greater BMI at both time points (Table 3). The prevalence of obesity was lower when using the IOTF definition compared to the WHO definition at both 13 years (3.54 vs 5.71%) and 16 years (3.85 vs 4.99%).

### *Association of different types of abuse with obesity*

The adjusted associations between any episode of sexual abuse, and any and cumulative physical and emotional abuse and later obesity, overweight and BMI are shown in table 4. No association was observed between childhood sexual, physical or emotional abuse and the prevalence of obesity or overweight at either 13 or 16 years. Interaction analyses did not

reveal any association with gender on the relationship between any type of abuse and overweight or obesity, at either 13 or 16 years (data not shown).

*Trajectories of BMI during adolescence:*

The fractional polynomials revealed that the best transformation of the age terms (based on the lowest deviance statistic) to model BMI during adolescence, was age<sup>2</sup>. For each of the three types of abuse, there were no differences in BMI size at the mean age (15.64 years), as reflected in each of the dummy variables and their 95% confidence intervals including the null value. However, for physical and emotional abuse there did appear to be weak evidence for a negative association between abuse and BMI trajectories (relative to no abuse), as evidenced by the negative interactions (-0.004; 95% CI: -0.006 - -0.001 and -0.002; 95% CI: -0.004- -0.001, for physical and emotional abuse, respectively)) between abuse and the age coefficient. This was not the case for sexual abuse. Supplementary tables 1-3 provide the adjusted parameter estimates for the longitudinal models and supplementary figures 1-3 provide plots of BMI trajectories during adolescence by type of abuse.

## **Discussion:**

In this large population study, no association was identified between abuse (emotional, physical or sexual abuse) up to the age of 11 years and obesity or overweight at 13 or 16 years. Our longitudinal analysis for physical and emotional abuse, revealed weak evidence for a negative association between abuse and BMI trajectories over the course of adolescence, but this was not seen for sexual abuse. This lack of positive association is in contrast to studies in adulthood and suggests that the relationship previously observed between child abuse and obesity in adults, may not be true in adolescence.

The large sample size and detailed data collected at multiple time points enabled us to investigate both the risk factors and the outcome in detail. Our data regarding BMI were likely to be robust as weight and height was measured by trained, independent observers as opposed to being self-reported. The longitudinal nature of this study allows us to investigate the temporal relationship between abuse and obesity, however as BMI in earlier childhood was not accounted for, the possibility of reverse causality for the BMI trajectory finding cannot be ruled out.

Whether abuse predicts adolescent obesity is controversial. Whilst the findings of some studies have suggested no relationship (as in our study), others have suggested that child abuse is associated with obesity, but with differing relationships for different types of abuse. Our results were consistent with a study which examined the rates of child maltreatment in a group of adolescent patients undergoing weight loss surgery in whom levels of maltreatment were not found to differ from the national base rates.<sup>16</sup> A British study (n ~ 15,000) found that abuse was not associated with increased BMI in childhood, but physical abuse was

associated with increased BMI gain in adulthood.<sup>17</sup> However, no association was identified with emotional abuse or neglect. The same study showed that BMI in childhood was lower or no different in children exposed to abuse than in those not exposed to abuse. Similarly, in a prospective American study no difference was found in the rate of obesity in childhood or adolescence, but by young adulthood (ages 20-27 years), abused female subjects were more likely to be obese (42.3%) than their non-abused female counterparts (28.4%).<sup>18</sup> A community based study from the USA (n=454), found that BMI trajectories in children differed according to the type of abuse, with sexually abused or neglected girls having a lower BMI than non-abused individuals until the age of 16-17 years when their BMI became higher than non-abused individuals.<sup>28</sup>

Three recent meta-analyses looking at the association between childhood abuse and later adult obesity indicate that child abuse of all types was associated with an increased risk of developing obesity (OR 1.26-1.36) over the life-course.<sup>29,30,31</sup> Two of these analyses also reported a dose-response relationship, with severe abuse being more strongly associated, than less severe abuse, with adult obesity.<sup>30,31</sup> Again, a large USA cohort study (n = 10,774) showed an increased risk of severe obesity in adulthood in individuals who reported having experienced both sexual and physical abuse during childhood compared to those with no history of abuse.<sup>32</sup> In a younger age group, a prospective cohort study (n=2461) in Australia showed that young adult women aged 21 years who had experienced penetrative sexual abuse had on average, a BMI that was 2.29 kg/m<sup>2</sup> greater compared to their non-abused counterparts, but no difference for those who experienced non-penetrative sexual abuse.<sup>33</sup> It is possible that the results of these studies differ from ours as many of them were retrospective, used self-reported data on abuse and studied the association in adulthood. Therefore, it is likely that the sample size of abused individuals was larger. It should also be

noted that there was not any data available in this present study to analyse on abuse during adolescence only abuse before the age of 11 years. It is also possible that the mechanisms conferring susceptibility to becoming obese in response to life stressors may differ between adults and adolescents.

In some respects, this study provides data on the reassuring lack of identifiable associations between three of the four types of child safeguarding issues (sexual, physical and emotional abuse) and concurrent adolescent over-weight and obesity. Given the apparent associations between adult obesity and various forms of childhood abuse, there has always been a question as to whether childhood obesity might also be linked to these factors.

There are a number of potential limitations of this study. As is commonly observed in longitudinal studies, loss-to follow-up was apparent in our study, with increasing amounts of missing data with advancing age. The 4205 and 3251 adolescents included in the cross-sectional and longitudinal analyses respectively, represent a minority of the approximately 14,000 mother-child dyads who were originally enrolled into the study. It has been shown that adolescents remaining in the ALSPAC cohort at ages 16-18 were less likely to be eligible for free school meals<sup>25</sup> and their mothers were more likely to be university educated<sup>34</sup>. As poverty and decreasing parental education has been observed to increase the risk of a child being abused<sup>35,36</sup> and being obese<sup>37,38</sup> by only performing a complete case analysis this may have biased our findings.

Unfortunately, as no data were collected on neglect this could not be used as a risk factor. The prevalence of sexual abuse up to the age of 11 years (0.45%) in this cohort was five



times higher than a recent UK study of abuse under 11 years by parent or caregivers<sup>39</sup>, but between ten and twenty-five times lower than previously reported throughout the whole of childhood by any adult.<sup>39,40</sup> Prevalence of physical abuse was consistent with previous studies and those for emotional abuse were double those previously reported.<sup>39,40</sup> Sexual abuse may have been significantly underreported in our study due to reliance on only parental reports and a possible unwillingness for parents to disclose whether they or their partners had been the perpetrator of sexual abuse even though the reporting was anonymous. Many victims of child abuse do not report abuse to their parents during childhood or at all throughout their lives. Furthermore, questionnaires asked only about abuse by resident care-givers and a recent study implied that a large proportion of sexual abuse is perpetrated by non-resident adults<sup>39</sup>. Additionally, a number of the families with abuse which was reported to social services dropped out of the study and therefore this likely introduced further bias. Under-reporting of abuse, especially of a sexual type, will have reduced our power to detect an association.

A further longitudinal study following children up into adulthood, using both parental and child reports, and data record linkage to social care and including abuse by non-resident adults would enable researchers to reduce under reporting, particularly of sexual abuse.

Neglect, the fourth type of abuse, was not included as a factor within the ALSPAC cohort and it would be necessary to include this in any future studies, to provide a more complete picture of possible associations of abuse of any kind with subsequent obesity. Overall, in this study no relationship was found between pre-adolescent child abuse of any kind and adolescent obesity in this cohort, although previous work has strongly suggested that victims of child abuse are at an increased risk of obesity in later life.

**Authors Contributions:**

Dr Hawton interpreted the data, drafted the initial manuscript, and approved the final manuscript as submitted.

Dr Norris carried out the initial analyses, critically reviewed the manuscript, and approved the final manuscript as submitted.

Prof Crawley conceptualised and designed the study, drafted the initial manuscript, and approved the final manuscript as submitted.

Prof Shield conceptualised and designed the study, critically reviewed the manuscript, and approved the final manuscript as submitted.

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**Figure/table legends:**

Table 1: Descriptive statistics for those with complete data for child abuse variables and BMI at 13 and 16 years (n=4205) and those with missing data

Table 2: Descriptive statistics (n ;%) on the number of abuse episodes experienced

Table 3: Prevalence of Obesity at age 13 and 16 years in sample using IOTF and WHO definitions

Table 4: Relationship between child sexual, physical & emotional abuse and adolescent overweight and obesity at age 13 and 16 years (n=4205)

Supplementary table 1: Relationship between child sexual abuse and BMI trajectories during adolescence (n=3251)

Supplementary table 2: Relationship between child physical abuse and BMI trajectories during adolescence (n=3251)

Supplementary table 3: Relationship between child emotional abuse and BMI trajectories during adolescence (n=3251)

Supplementary Figure 1: Sexual abuse and BMI trajectories

Supplementary Figure 2: Physical abuse and BMI trajectories

Supplementary Figure 3: Emotional abuse and BMI trajectories